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XX. *An Account of some Galvanic Combinations, formed by the Arrangement of single metallic Plates and Fluids, analogous to the new Galvanic Apparatus of Mr. Volta. By Mr. Humphry Davy, Lecturer on Chemistry in the Royal Institution. Communicated by Benjamin Count of Rumford, V. P. R. S.*

Read June 18, 1801.

I. **A**LL the GALVANIC combinations analogous to the new apparatus of Mr. VOLTA, which have been heretofore described by experimentalists, consist (as far as my knowledge extends) of series containing at least two metallic substances, or one metal and charcoal, and a stratum of fluid. And it has been generally supposed, that their agencies are, in some measure, connected with the different powers of the metals to conduct electricity. But I have found that an accumulation of GALVANIC influence, exactly similar to the accumulation in the common pile, may be produced by the arrangement of single metallic plates, or arcs, with different strata of fluids.

The train of reasoning which led to the discovery of this fact, was produced by the observation of some phænomena relating to the connection of chemical changes with the evolution of GALVANIC power.

It appeared, in several experiments, that series of double metallic plates, incapable of acting as GALVANIC combinations, when arranged in the proper order, with portions of water, were readily made to produce GALVANIC effects, by being alternated with

acids, or other fluids capable of oxidating one only of the metals of the series. Thus, double plates, composed of silver and gold, (metals which have been supposed to differ very little in their powers of conducting electricity,) produced GALVANIC action, when placed in contact, in the common order, with cloths moistened in diluted nitric acid. And copper and silver acted powerfully with nitrate of mercury.

These facts induced me to suppose, that the alternation of two metallic bodies with fluids, was essential to the production of accumulated GALVANIC influence, only so far as it furnished two conducting surfaces of different degrees of oxidability; and that this production would take place, if single metallic plates could be connected together by different fluids, in such a manner that one of their surfaces only should undergo oxidation, the arrangement being regular.

On this supposition, I made a number of experiments on different arrangements of single metals and fluids; and, after many various processes, I was enabled to ascertain, that many of these arrangements could be made active, not only when oxidations, but likewise when other chemical changes were going on in some of their parts.

In describing the different GALVANIC combinations formed by single metallic plates and fluids, I shall divide them into three classes, following, in the arrangement, the order of time with regard to discovery.

II. The first and most feeble class is composed, whenever single metallic plates, or arcs, are arranged in such a manner that two of their surfaces, or ends opposite to each other, are in contact with different fluids, one capable, and the other incapable, of oxidating the metal. In this case, if the series are

numerous, and in regular alternation, GALVANIC influence will be accumulated, analogous, in all its effects, to the influence of the common pile.

Tin, zinc, and some other easily oxidable metals, act most powerfully in this class of combinations.

If pieces of polished tin, about an inch square and $\frac{1}{20}$ of an inch thick, be connected with woollen cloths of the same size, (moistened, some in water, and some in diluted nitrous acid,) in the following order, tin, acid, water, and so on, till twenty series are put together, a feeble GALVANIC battery will be formed, capable of acting weakly on the organs of sense, and of slowly producing the common appearances in water; the wire from the oxidating surface of the plates evolving hydrogen; and the wire from the non-oxidating surface (when of silver) depositing oxide.

In all cases, when the batteries of the first class are erected perpendicularly, the cloth moistened in acid must be placed under the cloth moistened in water; and, in this arrangement, as the acid is specifically heavier than water, little or no mixture of the fluids will take place.

When zinc is employed, on account of its rapid oxidation in water containing atmospheric air, three cloths should be used; the first moistened in weak solution of sulphuret of potash, (which is possessed of no power of action upon zinc, and which prevents it from acting upon the water;) the second moistened in a solution of sulphate of potash, of greater specific gravity than the solution of sulphuret; and the third wetted in an oxidating fluid specifically heavier than either of the solutions. In this case, if the order be as follows, zinc, oxidating solution, solution of sulphate of potash, solution of sulphuret of potash, very

little mixture of the fluids, or chemical action between them, will take place: and an alternation of twelve series of this kind, forms a battery capable of producing sensible effects.

III. The second class of GALVANIC combinations with single plates is formed, when plates, or arcs, composed of a metallic substance capable of acting upon sulphurated hydrogen, or upon sulphurets dissolved in water, are formed into series, with portions of a solution of sulphuret of potash, and water, in such a manner that one side of every plate, or arc, is in contact with water, whilst the opposite side is acted on by the solution of sulphuret. Under these circumstances, when the alternation is regular, and the number of series sufficiently great, GALVANIC power is evolved; and water, placed in the circuit with silver wires, is acted on; oxide being deposited on the wire connected with the side of the plate undergoing chemical alteration, whilst hydrogen is evolved from the side in contact with water.

Silver, copper, and lead, are each capable of forming this combination. Plates made from either of those metals, may be arranged with cloths, (moistened, some in water, and others in solution of sulphuret of potash,) in the following order, metal, cloth moistened in sulphuret of potash, cloth moistened in water, and so on.

Eight series will produce sensible effects; and the wire from the top of the pile produces oxide.

Copper is more active, in this class of batteries, than silver; and silver more active than lead.

IV. The third and most powerful class of GALVANIC batteries, constructed with fluids and single metals, is formed, when metallic substances oxidable in acids, and capable of acting on solutions of sulphurets, are connected, as plates, with oxidating

fluids and solutions of sulphuret of potash, in such a manner that the opposite sides of every plate may be undergoing different chemical changes; the mode of alternation being regular.

The same metals that act in the second class, may be used in the third class; and the order of their powers is similar. The pile may be erected in the same manner as the pile with zinc in the first class; the cloths moistened in acid being separated from those moistened in solution of sulphuret, by a third cloth, soaked in solution of sulphate of potash.

Three plates of copper, or silver, arranged in this manner, in the just order, produce sensible effects; and twelve or thirteen series are capable of giving weak shocks, and of rapidly producing gas and oxide in water; the wire connected with the oxidating end of the apparatus evolving hydrogen; and the wire attached to the end acting on the sulphuret, depositing oxide when composed of silver, and generating oxygen when of gold.

V. In all the single metallic piles constructed with cloths, the action is very transient: the decomposition of the acids, and of the sulphurets, is generally completed in a few minutes; and, in consequence, the GALVANIC influence ceases to be evolved. The arrangement of all the different series may, however, (by means of an apparatus constructed after the ideas of Count RUMFORD,) be made in such a manner as to give considerable permanency to their effects. This apparatus is a box, covered with cement incapable of conducting electricity, and composed of three pieces of mahogany, each containing grooves capable of receiving the edges of the different plates proper for composing the series. One half of these plates must be composed of horn, or glass, and the other half of metallic substances; and

the conductors of electricity, and the non-conductors, must be alternately cemented into the grooves, so as to form water-tight cells.

When the apparatus is used, these cells are filled, in the GALVANIC order, with different solutions, according to the class of the combination; and connected in pairs with each other, by slips of moistened cloth, carried over the non-conducting plates.

A combination of fifty copper-plates, arranged in this manner, with weak solutions of nitrous acid, or nitrate of ammoniac, and sulphuret of potash, gives pretty strong shocks, rapidly evolves gas from water, and affects the condensing electrometer.

It does not lose its power of action for many hours; and, when this power is lost, it may be restored by the addition of small quantities of concentrated solutions of the proper chemical agents to the fluids in the different cells.

From two experiments made on copper and silver, it would appear, that the single metallic batteries act equally well, when the metals made use of are slightly alloyed, and when they are in a state of purity.